

# EXHIBIT 2

## **Fallows Associates** Plastics Consultants

Dec 20, 2013

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2300 North Mayfair Road  
Milwaukee, WI 53226

**Subject: Wisconsin Consolidated Litigation Concerning Electrolux Dryers**

### **I. Background and Experience**

We have been retained by plaintiffs in the cases consolidated under American Family Mutual Insurance Company, General Casualty Company of Wisconsin, Country Mutual Insurance Company. And Wisconsin Mutual Insurance Company (Plaintiffs) v. Electrolux Home Products Inc (Defendant), Case No.: 3:11-cv-00678 (SLC), to analyze the Electrolux Dryer design, in particular the selection of plastic components used in the air duct and blower housing. This report summarizes our qualifications and expertise relevant to this matter, as well as the results of our inspections, technical review, analysis, and testing. All of our opinions are with a reasonable degree of engineering certainty.

My name is Joe Fallows. My education is as a Mechanical Engineer, with 34 years of experience with design, and commercialization of plastic products. I worked in and managed application development groups for GE (General Electric) Plastics (the largest supplier of engineering thermoplastics in the world) for 9 years. In that capacity I and the GE application development group worked with Original Equipment Manufacturer's engineers to select the best plastics for their applications. This effort involved analysis of the environment for each plastic component. Performance requirements such as structural loading, impact, chemical resistance needs, maximum temperatures, and agency requirements such as CSA (Canadian Standards Association) and UL (Underwriters Laboratories). My expertise includes material and process selection, property interpretation, failure analysis, and product design and safety. I have been a plastics consultant for 24 years. I hold a number of patents, all of which involve the use and design of plastics materials.

My name is Sam Miller. I have a PhD in Polymer Engineering and Science and worked for 32 years with GE's Corporate Research, Appliances, and Plastics Businesses (focused entirely on plastics). In each of these businesses, I worked to build labs for characterization and identification of materials and understanding plastic applications failures. At GE Plastics I ran the US Materials Characterization Laboratories and the US Application Testing Laboratories. Over the years these technical groups had responsibility for polymer processing support, full

polymer characterization (including flammability), maintaining UL Certifications, and application testing (failure analysis). These services were provided for the full range of GE Plastics resins and many direct competitive polymers.

A curriculum vitae for each of us and a list of all publications authored by either of us in the previous 10 years is attached as Appendix A. A list of all other cases in which, during the previous 4 years, either of us have testified as an expert at trial or by deposition is attached as Appendix B.

Our compensation for this matter is \$200 per hour.

## **II. Documents Reviewed and Right to Change our Opinion**

In reaching our opinion we have reviewed all information received prior to Dec 20, 2013. The information we reviewed is listed in Appendix C. We reserve a right to modify our opinions if a review of documents received after Dec 20, 2013 reveals additional information.

## **III. Overview of Plastic Selection in Product Design and Development.**

Key engineering issues that a product manufacturer must address when using plastics in product design are: (1) whether plastic is an appropriate material for the design and, if so, (2) what plastic is appropriate for the particular product.

At all relevant times, even if a manufacturer lacked the expertise in-house to select the appropriate plastic, there were (and still are) numerous outside sources of expertise. By the late 1970's and early 1980's, GE Plastics and its competitors all had plastics design brochures that were free and easily accessible to any manufacturer. They all had field marketing forces that called on every manufacturer they could find, and they tried to help those engineering groups select the correct plastic by obtaining design drawings, and performance requirements, and sending those to the headquarters application development groups at the plastics suppliers. From there, one-on-one discussions between the plastics supplier's application development engineer and the manufacturer's engineers would take place. Performance requirements were discussed. Often these requirements were based upon prototype performance, or experience with previous models in the field. Those requirements were then matched with measured material properties of the various grades of plastic such as tensile strength, chemical resistance, impact, heat resistance, and flammability rating, among others.

At all relevant times, information about the specific material properties of various plastics made by different manufacturers was also widely available. In the 1980s, and continuing to this day, UL maintained a comprehensive library of plastics for which many material properties had been tested and recorded. These were recorded in what UL called "yellow cards". A plastic was usually rated at several thicknesses for various electrical and mechanical properties. One property in particular was (and still is) Flame Class. This Flame Class rating is tied to a testing protocol and common flame rating specification known as Underwriters Laboratories Test Number 94 (UL94). Flame Class ratings span from no flame retardant (HB) through increasing levels V-2, V-1, V-0 to 5Va and 5Vb; the last of which are very flame retardant (see Figure 1, below). Often a higher Flame Class can be achieved merely by increasing wall thickness.

QMFZ2 Component - Plastics

E123456

Plastics Company, Ltd.

1285 Walt Whitman Road, Melville, NY 11747 USA

ABC123

Polyamide 66 (PA66), furnished as pellets

	Min Thk	Flame			RTI	RTI	RTI
Color	(mm)	Class	HWI	HAI	Elec	Imp	Str
ALL	0.40	HB	-	-	65	65	65
	0.71	V-2	-	-	125	80	80
	1.5	V-2	3	0	125	80	85
	3.0	V-2	2	0	125	80	90

Comparative Tracking Index (CTI): 0

Dimensional Stability (%): 1.0

High-Voltage Arc Tracking Rate (HVTR): 0

High Volt, Low Current Arc Resis (D495): 4

Dielectric Strength (kV/mm): 15

Volume Resistivity (10xohm-cm): 14

UL94 small-scale test data does not pertain to building materials, furnishings and related contents. UL94 small-scale test data is intended solely for determining the flammability of plastic materials used in the components and parts of end-product devices and appliances, where the acceptability of the combination is determined by Underwriters Laboratories Inc.

Report Date: 6/19/1999

Underwriters Laboratories Inc®

Figure 1 – A sample UL yellow card showing Flame Class ratings at various thicknesses.

In the yellow card shown above, a thermoplastic, Nylon 66, is evaluated at 0.4, 0.71, 1.5 and 3.0mm of thickness. As the test specimens get thicker, the Flame Class rating for this plastic (with no flame retardant) actually improves from HB to V-2.

Plastics producers like GE Plastics competed to produce V-O and 5V (most flame retardant) rated plastics at the thinnest wall possible. This meant that their clients could mold flame retardant materials in thin walls, saving material cost and molding cycle time. There was a huge focus on this throughout the 1980's and through today.

Similarly, at all relevant times, plastics suppliers offered a ladder of heat resistant materials. A higher heat resistant material offered designers greater capabilities for their products. Temperature resistance was measured in several ways and one of the most commonly discussed and compared measures was the Heat Deflection Temperature, or Heat Distortion Temperature (HDT). This is an ASTM (American Society for Testing and Materials) test (D648) that measures the temperature at which a standard geometry specimen placed under load deflects a predetermined amount. The higher the HDT, the more heat resistant a plastic is. The practical utility of higher heat resistance is that the plastics can support the same stress at higher temperatures than a lower heat resistant plastic (assuming fillers are the same). The plastic with a higher heat resistance will maintain its shape while lower heat resistant plastics in the same environment will distort or outright melt.

Thus, at all relevant times, any manufacturer that knew a plastic component of its product could be exposed to direct flame, or even high heat, had many options available with regard to plastics having flame retardant and also heat resistant properties.

#### IV. Overview of UL Flame Rating

Basic polyolefins (polypropylene and polyethylene) are among the most flammable of the commonly-used plastics. Polyolefin polymers are very long, basic carbon chains that have high molecular weight (MW). The precursors to these high MW polymers are simple gasses (ethane, butane) and liquids (hexane, octane or gasoline). If these polymers are not fire retarded, they easily begin to degrade back to flammable gasses, which continue to feed a fire. Fire retardants can be added to polypropylene to slow the decomposition and limit its ability to support a flame.

UL94 Flame Ratings group materials into categories based on their flammability. The UL94 Test Procedures are independent of the material tested. The following is a summary of the test descriptions as given in the GE Plastics Engineering Design Guide (2002) pages 2-58 and 2-59:

Most electrical applications which are intended for home or industrial use must meet some type of flammability specification. The intent of these specifications is to reduce the potential for fires resulting from sparks, arcing, or overheating of electrical components. A common flame rating specification is Underwriters Laboratories Test Number 94 (UL94).

GE Plastics Engineering Guide at 2-58 (2002).

UL94 rates materials for flammability using specified test results for classification. The classifications are given with a minimum thickness. These ratings are referred to in actual device evaluations and may be required in the UL listing process.

*Id.* at 2-59.

The following concise description of the various UL94 tests and flame ratings can be found on the Underwriters Laboratories' websites.<sup>1</sup>

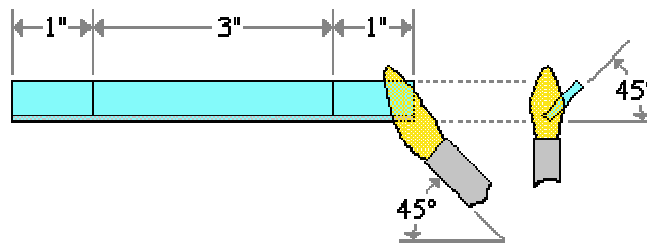
There are 6 flame classifications specified in UL94 that are assigned to injection moldable polymers based on the results of these small-scale flame tests. These classifications (5VA, 5VB, V-0, V-1, V-2, HB) relate to materials commonly used in manufacturing enclosures, structural parts and insulators found in consumer electronic products, such as clothes dryers, utilizing the following test procedures.

Horizontal Testing (HB) Procedure: A specimen is supported in a horizontal position and is tilted at 45°. A flame is applied to the end of the specimen for 30 seconds or until the flame reaches the 1 inch mark. If the specimen continues to burn after the removal of the flame, the time for the specimen to burn between the 1 and 4 inch marks is recorded. If the specimen stops

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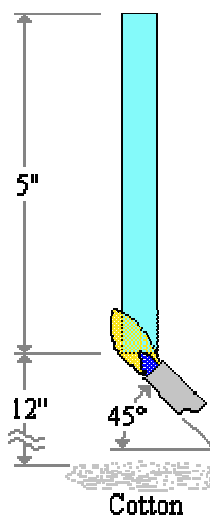
<sup>1</sup> UL 94, the Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing, <http://www.ul.com/global/eng/pages/offerings/industries/chemicals/plastics/testing/flame/> (last accessed Oct. 19, 2013), and UL 94 Flame Rating, [http://www.ides.com/property\\_descriptions/UL94.asp](http://www.ides.com/property_descriptions/UL94.asp) (last accessed Oct. 19, 2013).

burning before the flame spreads to the 4 inch mark, the time of combustion and damaged length between the two marks is recorded. Three specimens are tested for each thickness.



Rating	Requirements
HB	<ul style="list-style-type: none"> <li>Specimens must not have a burning rate greater than 1.5 inches/minute for thicknesses between 0.120 and 0.500 inches and 3 inches/minute for thicknesses less than 0.120 inches.</li> <li>Specimens must stop burning before the flame reaches the 4 inch mark.</li> </ul>

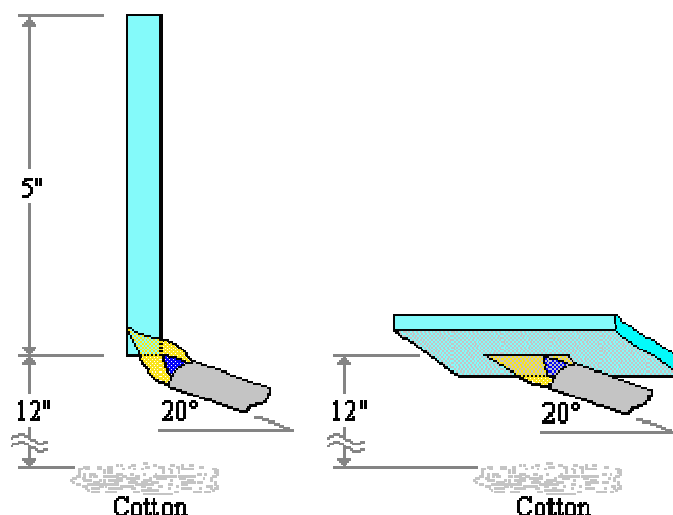
Vertical testing (V-0, V-1, V-2) Procedure: A specimen is supported in a vertical position and a flame is applied to the bottom of the specimen. The flame is applied for ten seconds and then removed until flaming stops at which time the flame is reapplied for another ten seconds and then removed. Two sets of five specimens are tested. The two sets are conditioned under different conditions.



Rating	Requirements
V-0	<ul style="list-style-type: none"> <li>Specimens must not burn with flaming combustion for more than 10 seconds after either test flame application.</li> <li>Total flaming combustion time must not exceed 50 seconds for each set of 5</li> </ul>

	<p>specimens.</p> <ul style="list-style-type: none"> <li>• Specimens must not burn with flaming or glowing combustion up to the specimen holding clamp.</li> <li>• Specimens must not drip flaming particles that ignite the cotton.</li> <li>• No specimen can have glowing combustion remain for longer than 30 seconds after removal of the test flame.</li> </ul>
V-1	<ul style="list-style-type: none"> <li>• Specimens must not burn with flaming combustion for more than 30 seconds after either test flame application.</li> <li>• Total flaming combustion time must not exceed 250 seconds for each set of 5 specimens.</li> <li>• Specimens must not burn with flaming or glowing combustion up to the specimen holding clamp.</li> <li>• Specimens must not drip flaming particles that ignite the cotton.</li> <li>• No specimen can have glowing combustion remain for longer than 60 seconds after removal of the test flame.</li> </ul>
V-2	<ul style="list-style-type: none"> <li>• Specimens must not burn with flaming combustion for more than 30 seconds after either test flame application.</li> <li>• Total flaming combustion time must not exceed 250 seconds for each set of 5 specimens.</li> <li>• Specimens must not burn with flaming or glowing combustion up to the specimen holding clamp.</li> <li>• Specimens can drip flaming particles that ignite the cotton.</li> <li>• No specimen can have glowing combustion remain for longer than 60 seconds after removal of the test flame.</li> </ul>

Vertical Testing (5VA, 5VB) Procedure: Testing is done on both bar and plaque specimens. A bar specimen is supported in a vertical position and a flame is applied to one of the lower corners of the specimen at a 20° angle. The flame is applied for 5 seconds and is removed for 5 seconds. The flame application and removal is repeated five times. The procedure for plaques is the same as for bars except that the plaque specimen is mounted horizontally and a flame is applied to the center of the lower surface of the plaque.



Rating	Requirements
5VA	<ul style="list-style-type: none"> <li>Specimens must not have any flaming or glowing combustion for more than 60 seconds after the five flame applications.</li> <li>Specimens must not drip flaming particles that ignite the cotton.</li> <li>Plaque specimens must not exhibit burn through (a hole).</li> </ul>
5VB	<ul style="list-style-type: none"> <li>Specimens must not have any flaming or glowing combustion for more than 60 seconds after the five flame applications.</li> <li>Specimens must not drip flaming particles that ignite the cotton.</li> <li>Plaque specimens may exhibit burn through (a hole).</li> </ul>

As produced, without fire inhibitors, most thermoplastic polymers will readily support a fire when an ignition source is provided. HB rated plastics have no flame retardant in them. A material classified as 5VA or 5VB is subjected to a flame ignition source “that is approximately five times more severe than that used in the V-0, V-1, V-2 and HB tests,” however, “and the specimens may not drip any flaming particles.”<sup>2</sup>

#### V. Material Evaluations Must Be Based upon both Environment and Safety.

When designing a product using plastics, the product design engineer must select materials that meet the product’s predicted or measured environmental requirements. In addition, it is often necessary to build prototypes from the materials selected and test them to ensure performance.

<sup>2</sup> UL 94, the Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing, <http://www.ul.com/global/eng/pages/offering/industries/chemicals/plastics/testing/flame/> (last accessed Oct. 19, 2013).

Safety is a key consideration in deciding which plastic to use in a product design (or whether to use plastic at all). By way of example, Sam Miller was a safety leader during his years of laboratory work at GE Plastics. Throughout his industrial career, regularly scheduled Safety Meetings have been part of working in a laboratory. Industrial Safety Meetings, scheduled to include everybody working at a plant site, are used to introduce safety to new people in the area, as well as reinforce good safety practices among the long-time workers. The main line of thinking in these meetings is to stress common sense responses to common problems that can arise. In plastic testing laboratories, fire safety is a regular topic of discussion. Any unintentional fires are investigated and discussed openly to prevent reoccurrences.

The first Fundamental Principle of the American Society of Mechanical Engineers Code of Ethics of Engineers (ASME P-15.7 2/1/12) states clearly:

Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.

This means that if a product you are responsible for designing has any potential for harming the public, it is your duty to minimize the likelihood of that product being the cause of public harm. An engineer should not ignore safety of the product he or she is designing.

An example of the role safety plays in material selection during the product design process is the “scaffolding interlock pins” project presented to the GE application development group in the 1980s. In essence, metal scaffolding used for construction projects would connect via plastic interlock pins that would insert inside the inner diameters of the tubing. The requirements for the plastics application were diligently recorded. Requirements such as the loads that could be expected in the worst case scenario, the temperature extremes from winter to summer in remote locations of the US, ultraviolet light exposure, and chemicals that might accidentally be spilled on the plastic interlocks, etc. And while plastics could have been selected, the reliability of the scaffolding was called into question simply because, should the interlock pins be damaged (rolled over by a truck, pinched, impact, etc.), the maintainers of the system, and the users of the system, would likely not have the ability to detect a pin failure before it happened. The pins might look fine even though they had been damaged. While the occurrence of a pin failure may have been low, the severity of failure, or the consequences resulting from pin failure, could be death of an individual on the scaffolding. By the formal measures of an FMEA (Failure Mode and Effects Analysis), the severity (SV) was high, the occurrence (OC) was probably low, but the ability to detect (DT) damage to a pin was difficult and would also get a high number. A high Risk Priority Number (RPN) was generated. The use of plastic material in this application was therefore deemed hazardous and no easy design change or modification could mitigate the hazard. GE Plastics decided not to pursue this application with the client.

## VI. Analysis

### A. Electrolux constructs the air duct out of its ball hitch dryers of plastic materials.

Electrolux chose to use injection molded thermoplastic as the material of construction for the air duct and blower housing in its ball hitch model dryers. Photos of examples of the air duct and blower housing from a 2003 Electrolux service manual are below (see Figure 2).

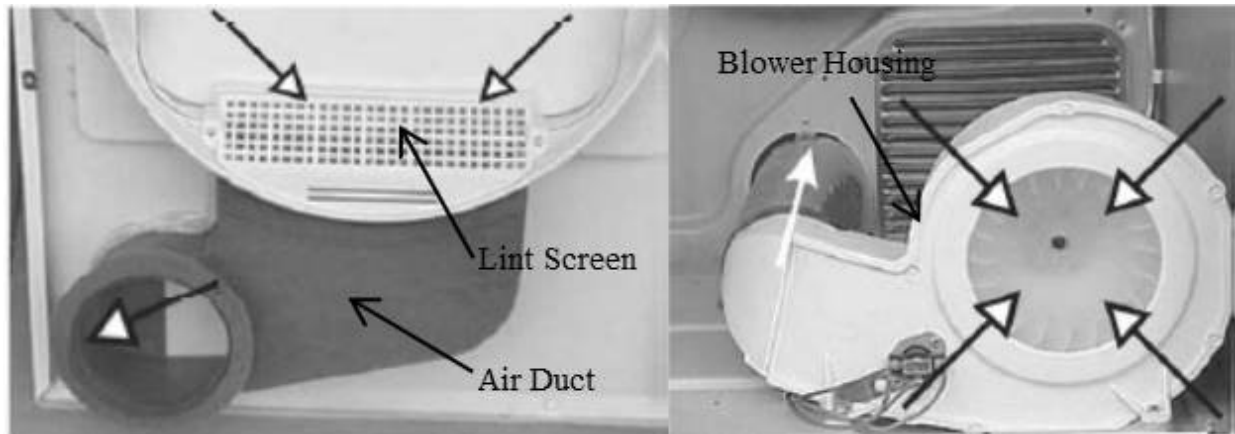


Figure 2 – Air Duct and Blower Housing from 2003 Electrolux service manual.

Electrolux chose to use polypropylene with a 20% talc filler. (See EHP LARSON 069447.) One of the grades of plastic called out on drawing number 316219 Rev Q (dated Aug 6, 1996) for the Electrolux air duct was Exxon PP1222F – color natural. The purpose of the talc is to make the polypropylene more rigid.

According to Electrolux, it manufactured the air duct and blower housing out of polypropylene having an UL94 HB rating.

- Q. When they made the Alliance dryer that started in 1996, Electrolux decided to use polypropylene in the air duct and the blower assembly; correct?
- A. It continued to choose the polypropylene from the Mansfield design.
- Q. Correct. But when it went to the new platform, the Alliance platform, they made the decision to continue that; correct?
- A. That's correct.
- Q. And that polypropylene used in those three parts, the air duct and blower assembly, including the blower housing and the blower wheel, had an HB rating; correct?
- A. I'm sorry, can you please repeat that question?

Q. The polypropylene that the Electrolux continued to use when it manufactured the Alliance dryer platform, that polypropylene had an HB flame rating; correct?

A. That's correct.

July 24, 2013, Deposition of Brian Ripley at 43-44. See also March 14, 2013 Deposition of Brian Ripley at 139:

Q. From 1995 onward, did Electrolux ever use plastics having fire inhibitors in its ball hitch dryers?

Mr. Williams: Same objection.

A. Not that I know of. Not that I know of, no.”

This is also reflected in drawings for the air duct used in the Electrolux dryers and the dryers Electrolux manufactured for GE (Drawing number 1316219 Rev Q, Bates EHP LARSON 069447). These reflect that the air duct could be made from either a UL94 HB rated polypropylene or a UL94 5V rated polypropylene.

**B. Electrolux failed to fully investigate the properties of the various plastics it considered and used in its dryer design.**

In the engineering world, fire is a known hazard in clothes dryers. See the March 14, 2013 deposition of Brian Ripley at 124-125. It is also clear that a dryer's air duct and blower housing can be exposed directly to the flame of a fire. For example, in his June 1, 2012 deposition, Mr. Ripley testified that he ran a test wherein he set a load on fire in a dryer drum and observed molten plastic from either the dryer air duct or blower housing leaking out of the dryer. *Id.* at 45 - 48. As reported by the Wright Group, Inc., its employees regularly see that the plastic air duct and blower housing in Electrolux dryers have melted and, during their in-house testing, the molten plastic comes out of the cabinetry flaming. Had flame-retarded plastics been used, the molten flaming plastic would self-extinguish instead of continuing to burn.

Deposition testimony makes clear that Electrolux had a fundamental lack of knowledge and understanding of flame retardant plastics. See the July 24, 2013, Deposition Brian Ripley at 44-45. For example:

Q: That [HB rating] means the polypropylene used to make the air duct, the blower wheel and the blower housing did not contain fire retardants; correct?

A: There might have been some fire retardants in there to get the HB rating.

*Id.* at 45. This statement is incorrect. HB rated materials do not have flame retardant in them. Virtually any non-flame retarded plastic can get an HB rating given the right wall thickness.

Mr. Ripley was also asked about Electrolux considering use of a 5V rated material for the plastic air duct, to which Ripley responded "It had a higher flame rating, but it would ignite at approximately the same temperature as the other plastic." *Id.* at 57. When asked if 5V-rated plastic in his opinion was safer than an HB-rated plastic in terms of fire containment, Mr. Ripley says "No." *Id.* at 75. These responses show a lack of understanding of what a fire retardant does. A 5VA or 5VB rated plastic would be safer in any fire situation than an HB rated plastic. The fire retardants in a 5V rated plastic slow polymer degradation (degradation which produces flammable gasses). The slowed degradation releases flammable gasses at a slower rate, so the fire is starved for fuel. (This is the mechanism for a combustion failure in a FR (or fire retardant) polypropylene. Other polymers can attain their FR performance through different mechanisms such as char formation.) When a fire retardant polypropylene is ignited, the flame retardant slows the heating and helps prevent the un-ignited plastic structure from distorting and dripping as readily as an HB plastic would have. A 5VA or 5VB rated plastic would tend toward self-extinguishment once ignited. At the very least, this would give a home's occupants more time to get out of the house if they were alerted to the dryer fire.

Mr. Ripley's responses also show that Electrolux apparently failed to investigate, and thus learn, that there were plastics available with higher heat resistance at the time as well. Knowing that the plastic was going to be used in an environment that could potentially expose it to direct flame, Electrolux should have investigated whether it was appropriate to use plastics

with a higher heat deflection temperature (HDT) rating or even materials other than plastic. As previously discussed, a plastic with a higher heat resistance will maintain its shape, while lower heat resistant plastics in the same environment will distort or outright melt. A higher heat resistance would prolong the time until the plastic melted and flowed outside of the dryer.

Mr. Ripley was also asked why Electrolux decided not to use 5V rated plastics for its Electrolux-branded ball hitch dryers when the exact same part was being produced from a 5V rated plastic for units Electrolux manufactured for sale to GE. Mr. Ripley's response was, "The other issue is at that time the 5V plastics had bromine in them, which if it does ignite, it is highly toxic, and so there was -- there was some shying away from that from an environmental standpoint." *Id.* at 149. This is also incorrect. There was a lot of focus by the plastics supplier community in the mid-1980s to offer non-brominated fire retardant packages because of the emerging opposition from European standards and the likelihood that similar laws would be passed in the US. By the late 1990s, there were many options for non-brominated fire retardant plastics.

Only when given the challenge by GE to design a safer dryer did Electrolux investigate flame retardant plastics and metal for the air duct and blower housing. After identifying safer options for producing GE branded dryers, Electrolux failed to adopt that safer alternative for its own use.

**C. Electrolux failed to consider the environmental conditions its dryers would be exposed to and safety when it selected the HB rated plastic.**

**1. Electrolux engineers identified the lack of fire containment using HB rated plastics as a severe hazard early in the design process.**

Documents and deposition testimony make clear that Electrolux knew its ball hitch dryers could not pass a fire containment test referred to as the GE Severe Environmental Exposure (SEE) test. Documents and deposition testimony also make plain that Electrolux determined that replacing the air duct made of HB rated plastic with an air duct made from 5V rated plastic or metal allowed the dryer design to pass the SEE fire containment test. This is because an air duct made from HB rated plastic would provide no self-extinguishing function whatsoever and would only be an additional fuel source for a fire in the dryer cabinet.

In the mid and late 1990's, Electrolux evaluated other alternatives instead of using HB polypropylene and found them to be safer. The Electrolux "Alliance Dryer Burn Test" report 1995-0028 issued on April 3, 1995 (Exhibit 10) singles out "Alliance Number 6" as a test module that upon completion of the GE SEE test "is better than current production". This module had a metal air duct replacing the HB polypropylene air duct. In addition, there were modifications to the base that would channel molten plastic away from the front edge and into the base. "If the holes in the console were sealed and the dryer door fit better this dryer would almost certainly pass the two hour burn test." Compared to the then-current model which was "Alliance Number 1" in the burn test and which failed in 4 minutes, the modifications that were made to "Alliance Number 6" were clearly an improvement in product performance and safety.

Ironically, at the top of this Electrolux test report is its corporate guideline stating that “Frigidaire Company<sup>[3]</sup> shall be obsessed with leadership in the quality of everything we do, through relentless improvement and high standards that exceed customer expectations.” (Emphasis added.)

As stated above, Mr. Ripley reports that he conducted dryer fire containment tests in 1996 and the HB rated plastic melted and molten plastic seeped out of the bottom of the dryer, “and that was considered a failure.” See the June 1, 2012, Brian Ripley Deposition at page 48.

The April 28, 1997 letter from Dan Ryherd to Dan Thomas (Exhibit 145) talks about how both the stacked and free stand dryers did not pass the GE SEE test. Mr. Ryherd identifies two ways the dryer could pass the GE SEE test – by making either the air grille or the air duct out of sheet metal.

In October of 1997, Ripley wrote a letter (Exhibit 150) discussing the GE dryer and the fact that GE required a 5V Polypropylene material (referred to as PP FR 8-6) to mold the air duct and blower housing in dryers Electrolux manufactured for GE. Fire testing showed that this material allowed the dryer to pass GE SEE testing, while the HB polypropylene used on the Alliance line did not pass. The 5V polypropylene discussed in this letter passed the GE SEE burn test and was an improvement in fire performance over the HB polypropylene used in the Alliance dryer. In this memorandum, Ripley wrote that “this change [to 5V material in the air duct and blower housing] will be made across the entire dryer product.”

The November 12, 1997 letter from John Jergens to Mary Hall (Exhibit 151) discusses the required actions to resolve remaining issues if Electrolux was to produce the GE contract dryer. On the first page is a grid of issues and actions to resolve. The letter points out that Electrolux was able to pass the GE SEE fire test with a 5V plastic used to mold the air duct and blower housing, but not with the HB rated polypropylene. And yet penciled in the “action to resolve” box is a note that says “*Paul Bertrand’s decision is to use 5V on GE units only.*” According to published records, Paul Bertrand appears to have been Bill Topper’s superior who assumed the position of Executive Vice President of Operations at Frigidaire Home Products in the 1987-88 timeframe.<sup>4</sup> There appears to be no questioning of Paul Bertrand’s decision to use safer 5V rated plastic only in GE-branded dryers, even though Electrolux engineers such as Brian Ripley and others knew that dryers using the HB rated plastic presented a fire hazard potential.

Electrolux Design FMECAs from 1998, when it was investigating re-designing its dryer to pass the GE SEE fire containment test, show that it identified “flame escapes the dryer” as a hazard posing a risk of “injury or death of consumer from fire.” June 18, 2013 Allison Deposition Exhibits 104 and 105. An excerpt from one of the FMECAs (Exhibit 104), below, shows how, out of a highest score of “10,” Electrolux assigned a “10” for the severity of flame escaping the dryer, a “9” for the likelihood of an occurrence (all of the dryers have the same

<sup>3</sup> Frigidaire is one of the primary brands under which Electrolux sold its dryers during the class period.

<sup>4</sup> See EUREKA'S PARENT NAMES WORLDWIDE CHIEF FOR ELECTRICAL GOODS (1998), <http://goo.gl/xqkNCl>

improper design elements), and the ability to detect such a failure mode was deemed pretty easy at a “2” (since it would be clear to see if a flame escaped the dryer). In this analysis the Risk Priority Number is determined by multiplying the Severity (“10”) by the Occurrence (“9”) by the Detection (“2”) → RPN = 180:

### Design FMECA

Project Title: <u>PicEne Dryer</u>		Products Affected: <u>GEA Dryer</u>		Part Source: _____	
Project Number: <u>94-0148</u>		Team Members: <u>Banks*, Folmer*, Wiley, Long*</u>		Forecast Production Date: _____	
Part Name: <u>Console Blatten</u>		<u>Blum*, Ryherd*, Lavender, Pleshowski</u>		Subsystems Affected: _____	
Part Number: _____		* denotes attendance		FMECAs Referenced: _____	

Part Function	Potential Failure Mode	Potential Failure Effect(s)	SV	Potential Failure Cause(s)	OC	Design Verification(s)	DT	RPN
Enclose back half of the console.	Back half of console can be accessed by the consumer.	Agency violation. Injury or death of consumer from electric shock.	10	Improper design	9	DVR - FA and function.	1	90 (DV)
Provide a damper during the SEE Test.	Flame escapes the dryer.	Injury or death of consumer from fire	10	Improper design	9	DVR - SEE Test	2	180

Exhibit 104 – Electrolux Design FMECA

Mr. Ripley testified that “The higher the number, the more attention that would get put to it. I believe our threshold for acceptance is 125.” July 24, 2013 Brian Ripley deposition at 187-88. And the higher the RPN number, the greater the potential threat to the customer. *Id.* at 188. Mr. Ripley also explained that an RPN of 180 is “not an acceptable number,” and that “It’s high enough to get attention and be resolved.” *Id.* at 188-89. Mr. Ripley also explained that Electrolux’s policy is not to allow any product into production with a RPN above 125. *Id.* at 227.<sup>5</sup>

## 2. Electrolux disregarded engineering standards and consumer safety.

Electrolux’s continued use of HB rated plastics in the air duct and blower housing of its dryers was illogical and reckless, and violated basic engineering standards discussed above regarding (1) whether plastic is an appropriate material for the design and, if so, (2) what plastic is appropriate for the particular product.

Electrolux’s FMECA reflects how it identified “flame escapes the dryer” as a severe safety hazard that could result in “injury or death of consumer from fire” and that, with an RPN of 180, should have been resolved before allowing the dryer into production. Electrolux also determined that both its dryers did not pass the GE fire containment test, that the air duct and

<sup>5</sup> While these opinions apply to those dryers manufactured after GE SEE testing results were known, Electrolux should have performed engineering analysis many years earlier when they first introduced plastic air ducts and blower housings in order to determine the effects of a drum fire.

blower housing could be exposed to direct flame, and that the dryer design could be modified by manufacturing the air duct out of plastic having a UL94 5V rating.

We have also reviewed video of testing by the Wright Group showing how flaming, molten plastic seeps out of the right front corner of the Electrolux dryer and continues to burn.<sup>6</sup> Stills taken from that video show flaming, molten plastic seeping out of the lower right hand front corner of the dryer:



We understand that this was an Electrolux dryer with an air duct and blower housing made from HB rated plastic. Even if a 5V rated plastic melted and seeped out of the cabinet, it would tend to self-extinguish once outside the dryer cabinet and no longer exposed to the heat source.

We have also reviewed pictures assembled by the Wright Group showing a common and substantially similar burn pattern in the right front corner that we understand is produced by the HB rated plastic air duct and blower housing being consumed in a fire.<sup>7</sup> Electrolux's engineers either knew or should have known of this common and uniform pattern evidencing a major safety defect, as it is further evidence that an HB rated plastic was an inadequate material for the environment to which it could foreseeably be exposed.

Electrolux's decision to use an HB rated plastic to make product parts it knew could be exposed to direct flame was illogical and reckless. Electrolux developed solutions for its dryers to pass the GE SEE test that utilized alternate materials. Those were either UL94 5V rated plastics, or metal. Either material was an improvement over the HB plastics they were using. And yet Electrolux knowingly chose not to incorporate these improvements into its own Alliance line.

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<sup>6</sup> Video produced by the Wright Group.

<sup>7</sup> PDF, "Trap Duct Damage"

At all relevant times, Electrolux had a continuum of better design choice materials from which to manufacture the air duct and blower housing in its Alliance platform dryers. As explained herein, using a UL94 5V rated plastic was safer than HB rated plastic. A sheet metal air duct and blower housing would be even safer than flame retarded plastic.

Yet Electrolux decided to use HB rated plastic in its dryers and the safer 5V rated plastic only in the Alliance platform units it manufactured for GE.

Electrolux disregarded basic safety principles when it decided to make its own dryers using HB plastic with no fire retarding properties when it knew that it could make dryers like the ones it made for GE having air ducts made from a much safer 5V rated plastic. Electrolux knew the air duct, which collects flammable lint during normal use, could be exposed to flame. Moreover, Electrolux not only investigated using alternative materials, including metal, that could better withstand direct exposure to flame, but its investigation led it to conclude that two suitable materials existed – metal and 5V rated plastic. When GE demanded a safer dryer, Electrolux even chose one of those materials, the 5V plastic, and then designed and produced dryers for GE with air ducts all made from 5V rated plastic. Yet, at the very same time, Electrolux continued to manufacture its own dryers having air ducts and blower housings all made from HB rated plastics with no fire retardant properties.

Cost was not a factor. Electrolux used the same molds to make air ducts using 5V rated plastic and HB rated plastic. July 24, 2013 Deposition of Brian Ripley at 191. So there were no retooling costs. The cost of the 5V rated plastic was also not a factor. James Allison, a designated representative of GE, testified that the cost difference would be “pennies.” June 18, 2013 Deposition of James Allison at 202, 203. Brian Ripley testified on Electrolux’s behalf that the total cost to manufacture an Alliance unit was \$120 and the cost to use 5V rated plastic was less than \$2 per unit. July 24, 2013 Deposition of Brian Ripley at 148, 178.

In fact, Electrolux’s representative testified that while cost was considered, the real reason it decided to continue using HB rated plastic was so it could meet design and production schedules. *Id.* at 150 - 151 (“to keep the schedule that we had in place on time, we stayed with the plastic that we were used to dealing with.”). Electrolux’s representative also testified that it saw fire containment as a “unique requirement for GE,” and that “there were ways that we could segregate the material and make sure GE received the correct material for what their specification was.” *Id.* at 174.

Electrolux also testified that what drove its decision to continue using HB rated plastics in the air duct and blower housing, and not the safer 5V rated plastic, was that UL—the standards-setting agency that publishes minimum standards for electric dryers—did not require it.<sup>8</sup> *Id.* at 72-73. For the air duct and blower housing, therefore, this meant finding a cheap plastic that could be injection molded into the needed shapes. Electrolux’s polymer choice was an HB rated polypropylene with mineral filler to stiffen the plastic. This approach is consistent with other evidence that Electrolux appears to rely primarily on UL and other industry-minimum

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<sup>8</sup> Electrolux applied this rationale to its gas ball hitch dryers, as well.

standards to select materials in its dryers. Brian Ripley testified that the design team was responsible for the decision on material selection, and that they looked to UL for the specification of the minimum required flammability. March 14, 2013, Deposition of Brian Ripley at 62. He also testified that a dryer that met the UL standards was a safe dryer. *Id.* at 145-46.

Such evidence shows that Electrolux either disregarded, or lacked an understanding of, the material selection process. It also shows that Electrolux's primary design concern in selecting the appropriate material was UL compliance, not safety. UL only lists plastic materials by their fire rating (UL Standard 94) at a given thickness. It is up to the end user of a material to determine the needed level of fire resistance in their particular application. UL determines the needed level of fire resistance in generic applications, but does not call out specific plastics for those applications: for example, UL does not keep a list of suggested polymers that can be used in a dryer blower housing or vent cover. UL only broadly suggests the level of flammability required for UL certification in the dryer unit. UL does not recommend a polymer for a blower housing or a vent cover. Rather UL provides a list of recognized polymer characterization tests (including mechanical, electrical, heat resistance, and flammability) that determine the minimum standards a material must meet to qualify for UL certification. These standards are continually under review with industry and they change over time to reflect current thinking on product safety. Simply put, the UL and similar voluntary standards Electrolux followed are minimum standards and a product can use all of the materials to comply with them and still be unsafe.

We have never before encountered a situation where a manufacturer identified a safety hazard that could result in consumer injury or death, determined that the plastic being used was inadequate and also determined that it was feasible to use a different material to guard against the safety hazard, but then decided to use the safer material in some, but not all, of the product models it manufactured. We have never encountered this situation, because this is the antithesis of engineering ethics and engineering standards regarding (1) whether plastic is an appropriate material for the design and, if so, (2) what plastic is appropriate for the particular product. No reasonable engineer would identify a safety hazard that could result in injury or death to the consumer, but then disregard a feasible solution on the basis that it was not required by a rating agency's minimum voluntary standard. Electrolux's disregard for safety is shown to be all the more egregious by Electrolux's own documents, which give this fire hazard of flame escaping the dryer an RPN rating of 180, which is so high that it should not have been allowed into production under Electrolux's own policies.

Electrolux willfully disregarded consumer safety when it chose not to consider the environment in which its dryers would be used and when it selected an HB rated plastic for its Alliance dryers.

## **VII. Conclusions**

Based on our review of the materials provided relating to Electrolux's design and development of the ball hitch dryers, we can state within a reasonable degree of engineering certainty that:

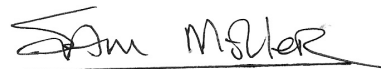
- Fire is a known hazard in dryer design by engineers in the industry, and it is reasonably foreseeable to Electrolux that the air duct and blower housing, both of which collect a flammable material (lint) during normal use, could be exposed to direct flame.
- A UL94 5VA or 5VB rated plastic would be safer in any fire situation than an HB rated plastic. In the event of a fire in the dryer cabinet, the flame retardant in a 5VA or 5VB rated plastic prevents the un-ignited plastic structure from distorting and dripping as readily as an HB rated plastic, and would tend toward self-extinguishment once the molten polymer flowed outside the dryer cabinet (unlike an HB plastic).
- Electrolux failed to use ordinary care and violated engineering standards and ethics in the design and selection of material in the air duct and blower housing of its dryers.
- Electrolux's decision to disregard its own determinations that the use of HB rated plastic material in this application was hazardous, and that a feasible design change or modification could mitigate the hazard, was illogical and exhibited a willful disregard for a common known risk to consumer safety.

This report summarizes opinions formed during our investigation and is based on information reviewed to date. These opinions are given within a reasonable degree of engineering certainty. If additional information becomes available we reserve the right to modify or append our opinions.

Sincerely,



W. Joseph Fallows



Sam Miller PhD

**APPENDIX A****W. JOSEPH FALLOWS III**

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Website – [www.fallowsapc.com](http://www.fallowsapc.com)

**PROFESSIONAL SUMMARY**

Polymer based product design and commercialization engineer with 30 years of technical marketing and industrial experience. Expertise includes failure analysis, product commercialization, intellectual property development, material selection, property interpretation, part design, concept development, and process selection. Success working for global industrial companies, and small startup businesses as a technical consultant. Joe is also an Expert Witness in product failure subrogation cases.

**EXPERIENCE****Fallows Associates Plastics Consultants****1989 - present**

Principal

Consultancy focusing on plastics failure analysis, polymer based new product development and commercialization. Also conduct training seminars, engineer-in-residence programs, concept development, and material / process selection.

**Terra Form Incorporated****1991 - 1994**

Managing Partner, Board of Directors

Terra Form developed, manufactured and marketed products from biodegradable polymers. Developed the first starch based thermoplastic golf tees and other golf accessories. Exported products to Southeast Asia, negotiated Intl. letters of credit, generated product marketing, and packaging for various market sub segments in the U.S. Successfully placed product in Walmart, Kmart and Target stores across the nation. Sold the business to a large golf products distributor.

**General Electric Corporation, Plastics Division****1980 - 1989**

Marketing Programs Manager -Lighting/Enclosure/Power Distribution

Application Development Manager - All Markets

Responsible for assisting OEM manufactures with new product commercialization, appropriate material selection, process selection, product design optimization, and failure analysis.

- Created the first flow modeling position in the polymer supplier industry.
- Moved the function of application development upstream to provide concept development to customers.

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- Initiated "Technical Tips" newsletter to customers.
- Created market specific training seminars for OEMs.

### **Union Carbide Corporation Carbon Products Division**

**1976 - 1980**

Senior Product Engineer – Pyrolitic Ceramics

Responsible for process control, product design, product costing, product quality, and interfacing with customers. Chemical Vapor Deposition (CVD), Chemical Vapor Reaction (CVR) processes were used to produce ultra high purity labware for the semiconductor market, and super tough pumps for the chemical processing industry.

### **EDUCATION**

Michigan State University    B.S. Mechanical Engineering

**1976**

Other Training:

- GE Technical Management Courses
- Marketing GE Plastics
- Kepner Tregoe Decision Making
- Interpersonal Communication Skills Development

**1980 - 1985**

### **PUBLICATIONS**

- Plastics Engineering, "Identifying Common Design Initiated Problems with Injection Molded Parts." (Dec 1982 issue)
- SPE Montreal Technical Conference: "Increase Profitability by Identifying Design Initiated Problems."

### **PATENTS**

- "Fan orifice structure and cover for outside enclosure of an air conditioning system" Patent # 5,066,194 (Nov. 19, 1991)
- "Grille for packaged terminal air conditioner" Patent #5,251,461 (Oct. 12, 1993)
- "Cover for the outside enclosure of an air conditioning system" Patent # 5,294,195 (Mar. 15, 1994)

- “Polymeric heat exchanger with ceramic material insert” Patent #5,623,988 (Apr. 29, 1997)
- “Plug finishing system and tool therefor” Patent #8,104,248 (Jan 31, 2012)
- “Plug finishing system and tool therefor” Patent #8,202,032 (Jun 19, 2012)

Dec 18, 2013

**SAM MILLER, PhD**

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**PROFESSIONAL SUMMARY**

Thirty three years working for General Electric Research and Development, GE Appliance Division, and GE Plastics Division as a Materials Scientist including nine years in technical management. Primarily concerned with material properties with respect to their environment, their loading state, and the rate of stress application. Able to make difficult concepts understandable through 12 years of teaching polymer science basics to engineers and salesmen. Strength at correlating science fundamentals and measured properties to application failures. Possess a thorough understanding of basic and organic chemistry through actual practice and lecturing at the university level. Worked as a trainer in six sigma fundamentals. Spent 30 in global technical work developing plastic materials and testing methods. Managed the technical development of GE Plastic's global recycle program.

**EXPERIENCE****Fallows Associates Plastics Consultants****2008 – Present**

Consultancy focusing on plastics failure analysis, chemical and physical methods of analysis, and interpretation of analytical data.

**University of Colorado,****Chemistry and Biochemistry Dept. and Student Academic Services Dept.****2004 - 2007**

Instructor in Chemistry and Organic Chemistry

Instructor in Organic Chemistry Laboratories

**General Electric Corporation, Plastics Division****1978 – 2004**Principal Scientist

Completed extensive research in Pressure/Volume/Temperature relationships to predict shrinkage and warpage in injection molded parts. Trained technical staff in new global research centers in Bangalore, India, and Shanghai, China.

Principal Materials Engineer

Led research and development efforts for new plastic products for a wide range of applications; primarily in wear resistance, antistatic behavior, low friction, and electrical conductivity.

Designed test method and built first block-on-pin wear testing apparatus.

Manager, Global Plastics Recycle Technology

Responsible for developing and implementing GE Plastics Global Recycle Technology Program.

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Manager, New Product Characterization

Managed a section charged with characterization of all new GE Plastics products.

Manager, Material Application and Commercialization Services

Managed a group responsible for characterization of all new polymeric products, and most new applications. Developed test methods and wrote specifications for mechanical characterization of plastics.

Manager, Product Services

Ran product characterization services for crystalline polymers. Developed and managed the first global database for plastic materials (ERIS – 1981).

Materials Scientist

Ran QC and characterization for a thermoset plastic venture (ARNOX).

**General Electric Corporation, Major Appliance Business****1975 – 1978**Development Engineer

Focused on elastomer modification of crystalline polymers. Studied rheological and mechanical properties and heterogeneous material performance<sup>2</sup>.

**General Electric Corporation, Research and Development Center****1973 – 1975**Research Training Engineer

Research in polymeric creep, crazing, fracture mechanics, rheology, and stress states. Designed and built a multi-station true-stress creep test machine.

**EDUCATION**Masters and PhD, Polymer Science and Engineering

University of Massachusetts, Amherst

**1998**Master of Chemical Engineering

Ohio University, Athens

**1973**Bachelor of Chemical Engineering

Ohio University, Athens

**1970**

GE's Six Sigma Training, Green Belt & Black Belt

**1992**

GE New Manager Development Training

**1987**

GE Leadership Technology Program

**1975**

## AREAS OF EXPERTISE

### *Properties of Plastic / Elastomeric Materials*

**Strength** Tensile, Flexural, Torsional, and Compressive including failure modes.  
**Modulus** Static, Dynamic, and Creep. Uniform, non-uniform materials and composites.  
**Impact** Notch sensitivity, uniaxial and biaxial stress states, rates of loading.  
**Creep** Tensile and flexure, creep rates, compliance, and rupture. Life predictions.  
**Pressure / Volume / Temperature (PVT)** effects from room temperature through degradation. (Authored the PVT chapter in the *Handbook of Molded Part Shrinkage and Warpage*<sup>3</sup>.  
**Color, haze, and transparency** of films and structures.  
**Aging and Weathering** effects on polymer aesthetics and performance.

### *Analysis Processes for Plastic Materials*

**Dynamic Mechanical Analysis (DMA)** of melts and solids. (Used to predict performance, understand temperature sensitivity, monitor cure rates, and connect melt and creep performance.)  
**Crystallization** processes and the effects of crystal types, sizes, and distributions on performance.  
**Viscoelasticity** and relaxation effects vs. temperature, time, and rate.  
**Ductile / Brittle Transitions** in plastic and elastic materials.  
**Fatigue** life and fatigue failures.  
**Microscopy**, both optical and electron beam. Morphology / performance relationships.  
**Light Scattering**, Reflection, Absorption, Transmission, and Color.  
**Fracture Mechanics** from classical analysis to practical understanding and use<sup>4,5,6</sup>.  
**Fracture Surface** interpretation.  
**Recycle recovery processes**<sup>7,8</sup>. (Identification, sorting, cleaning, and compounding)  
**Thermal Analysis (DSC, TGA, TMA, PVT)** operation and data analysis.  
**Nuclear Magnetic Resonance (NMR)** operation and data analysis.  
**Infrared Spectroscopy** operation and data analysis.

## PUBLICATIONS

1. Miller, S, Macrocyclic Polymers from Cyclic Oligomers of Poly(Butylene Terephthalate), University of Massachusetts, Polymer Science & Engineering Doctoral Thesis, May 1998.
2. Miller, S. "Inferences on Polypropylene/EPDM Blend Toughness from Morphology and Component Rheology", *Plastics and Rubber Inst.*, Toughening of Plastics (1978), pp 8.1 - 8.9.
3. Miller, S, Chapter 4; "Causes of Molded Part Variation: Material", in Handbook of Molded Part Shrinkage and Warpage, JM. Fisher, *Plastics Design Library / William Andrew, Inc.* (2003), pp 23-49,172-185.

4. Kambour, RP and Miller, S, "Single Grooved Double Cantilever Beam Fracture Specimens vs. Dougdale Specimens for estimating Shear Lip Propagation Energies: BPA Polycarbonate", J. Material Science, V11 (1976), p 823.
5. Kambour, RP and Miller, S, " $G_c$  versus Crack Velocity in Single Groove Double Cantilever Beam Specimens of Polycarbonate" J. Material Science, V11 (1976) p 1220-1226.
6. Kambour, RP and Miller, S "Plane-Strain Fracture Energy Instability and Mixed Mode Crack Propagation in Polycarbonate at Room Temperature" Journal of Polymer Science: Polymer Physics Edition, (1978) V16, p91-104.
7. Miller, S. "Cautions on the Use of Recycled Plastics", SPE Proceedings, New Orleans LA, 1993.
8. Miller, S. "Quality, Cost, and Value in Recycled Plastics", SPE Proceedings, Boston, MA, 1994
9. Miller, S. "Reading and Understanding Technical Datasheets for Thermoforming Processes", SPE Thermoforming Division Conference, (2004).

Dec 18, 2013

**Publications authored in the previous 10 years**

1. Fallows, J., Kirker, E. "CPVC Plastic Sprinkler Pipes and Fittings: What they are, how they fail, and how you can recover when they fail. NASP Annual Conference (Nov, 2011)

## APPENDIX B

### Fallows Testimony

Following is a list of cases and dates upon which I have been deposed, or provided trial testimony over the past 4 years.

United States District Court  
Northern District of California  
Oakland Courthouse  
June 25, 2013 (Deposition)  
**Jason Trabakoolas and Sheila Stetson, individually and on behalf of all others similarly situated (Plaintiffs)** v. Watts Water Technologies (Defendant)  
Case No. C-12-1172-YGR

Superior Court of New Hampshire  
Hillsborough County, Southern District  
Thomas and Karen Wilhelmsen and Concord Group Insurance (Plaintiff) v. **JC Plumbing & Heating (Defendant)** and Fluidmaster, Inc. (Defendant)  
Feb 16, 2010 (Court Testimony)  
Docket Nos. 05-C-0170 and 06-C-0004

Superior Court of Connecticut  
Judicial District of Hartford  
Sept 3, 2009 (Deposition)  
**Lesko Plumbing and Heating (Defendant)** vs. Standard Fire Insurance Co. (Plaintiff)  
Docket No. HHD CV-07-5012415-S

Superior Court of New Hampshire  
Hillsborough County Northern District  
May 27, 2009 (Deposition)  
Clark House vs. **Harvey Industries (Defendant)** vs. Gary Chicoine Construction Corporation.  
Docket No. 2008-C104

Last updated Aug 27, 2013

## APPENDIX C

### Facts and Data Considered

1. Third Amended Complaint against Electrolux, July 24, 2013 (Case 3:11-cv-00678-slc)
2. Electrolux Service Manual for Gas and Electric Dryers – 2002; EHP LARSON 000771
3. Electrolux Air Duct Drawing 1316219 Rev Q; EHP LARSON 069447
4. Brian Ripley Deposition of June 1, 2012
5. Brian Ripley Deposition of March 14, 2013, and exhibit 10
6. Brian Ripley Deposition of July 24, 2013, and exhibits 145, 150, 151
7. James Allison Deposition of June 18, 2013, and exhibits 104, 105
8. Carl King Deposition of March 26, 2013
9. Video of dryer burn tests from the Wright Group
10. Electrolux Dryer Fire Containment Testing (performed at The Wright Group), Oct 2013
11. Dryer Component Fire Testing (performed at The Wright Group), Oct 2013
12. We maintain a file of materials reviewed with respect to this case.